CLAIMS

What is claimed is:

1. A method of path protection in a network of nodes interconnected by communications links, each link having a capacity for carrying logical channels between nodes, the method comprising:

establishing a plurality of working paths through the nodes, each working path comprising logical channels of a series of links;

for each working path, precalculating an associated protection path comprising logical channels of a different series of links;

assigning a priority to each working path and associated protection path;

upon a failure event involving at least one of the links, switching the working paths that include the at least one failed link to their respective protection paths, with a higher priority protection path preempting one or more lower priority paths that share at least one link if the link capacity of the at least one shared link is otherwise exceeded by addition of the preempting protection path.

2. The method of Claim 1 wherein the higher priority protection paths preempt lower priority protection paths that share at least one link.

3. The method of Claim 1 wherein the higher priority protection paths preempt lower priority working paths that share at least one link.

4. The method of Claim 1 wherein precalculating an associated protection path includes assigning an associated protection path bandwidth as a percentage of a working path bandwidth associated with the corresponding working path.

5. The method of Claim 1 wherein the network comprises at least two overlapping areas of nodes and wherein establishing includes establishing a working path which traverses one or more areas of nodes and precalculating includes precalculating an associated protection path for each area through which the working path traverses; and upon a failure event involving the working path, switching a portion of the working path to the associated protection path for one of the areas that includes the failure event.

6. A method of failure notification in a communications network, the method comprising:

providing a communications network having at least two overlapping areas of nodes interconnected by communications links;

upon a failure event involving one of the communications links, broadcasting a failure message identifying the failed link, the broadcast being confined within the areas which includes the failed link.

7. The method of Claim 6 wherein broadcasting includes detecting the link failure at one or both of the nodes connected to the failed link, identifying nodes connected to the one or both detecting nodes that belong to the same areas as the failed link and sending the failure message only to such identified nodes.

8. The method of Claim 7 wherein broadcasting further includes:

at each node that receives the broadcast failure message, identifying nodes connected thereto which belong to the same areas as the failed link and sending the failure message only to such identified nodes.

9. The method of Claim 8 wherein the broadcast failure message includes a failure counter associated with the failed link, and wherein the method further includes:

at each node that detects the link failure, updating the failure counter for the failed link and inserting the updated failure counter value into the broadcast failure message;

at each node that receives the broadcast failure message, comparing a stored failure counter value for the failed link with the updated failure counter value in the received broadcast failure message and, if the updated failure counter value is less than or equal to the stored failure counter value, discarding the broadcast failure message; otherwise, replacing the stored failure counter value with the updated failure counter value and sending the broadcast failure message to identified nodes.

10. The method of Claim 9 further comprising synchronizing the failure message with a routing protocol message by including the updated failure counter in the routing protocol message.

11. The method of Claim 10 further comprising at each node that receives the routing protocol message, comparing a stored failure counter value for the failed link with the updated failure counter value in the received routing protocol message to determine whether the routing protocol message is synchronized with the broadcast failure message and discarding the routing protocol message if not synchronized.

12. The method of Claim 6 wherein broadcasting includes:

at one or more of the nodes, sending to a connected node a LAPD protocol unnumbered information frame containing the failure message and resending the failure message in another unnumbered information frame after a time interval unless an unnumbered acknowledgment frame containing the failure message is received from the connected node.

13. The method of Claim 6 wherein broadcasting includes:

at one or more of the nodes, sending to a connected node a LAPD protocol unnumbered information frame containing the failure message and periodically resending the failure message until an unnumbered acknowledgment frame containing the failure message is received from the connected node.

14. The method of Claim 6 wherein each node includes plural line cards, each line card terminating a link to another node, and wherein broadcasting includes:

detecting the link failure at one of the line cards connected to the failed link; sending a failure message to the other line cards on a message bus within the node of the detecting line card; at each of the other line cards, sending the failure message to the associated connected node.

15. The method of Claim 14 wherein sending at the detecting line card includes multicasting the failure message and periodically resending the failure message until an acknowledgment message is received from each of the other line cards.

16. The method of Claim 14 wherein the message bus carries high and low priority messages and wherein sending at the detecting line card includes sending the failure message at high priority.

17. The method of Claim 6 further comprising:

establishing a working path which traverses one or more areas of nodes, the working path comprising a series of links;

for each area through which the working path traverses, precalculating an associated protection path comprising a different series of links; and

if the working path includes the failed link, switching the working path to the associated protection path for one of the areas that includes the failed link.

18. In a network of nodes interconnected by communications links, apparatus at a node comprising:

a message bus; and

plural line cards connected to the message bus, each line card including a message bus interface circuit for sending and receiving messages on the bus, the messages comprising high and low priority messages having a message length that is bounded such that latency on the message bus is bounded.

19. The apparatus of Claim 18 wherein the message bus comprises a pair of redundant buses and the node includes an arbitration circuit for arbitrating access by the line cards to the redundant buses in a round-robin fashion.

20. The apparatus of Claim 18 wherein each line card includes an interface port for terminating a communications link to another node, the port having means for detecting a failure event involving the associated link, and wherein in response to such failure detection, a detecting line card sends a failure message at high priority on the message bus to other line cards.

21. In a network of nodes interconnected by communications links, a method of protection path switching comprising:

establishing a plurality of working paths, each working path including a working path connection between ports of a switch fabric in each node of a series of interconnected nodes;

at each node:

maintaining a protection path activation list for each communications link in the network, each list comprising an ordered listing of path entries, each path entry associated with a particular working path for that communications link and including at least one path activation command for effecting activation of a protection path connection between ports of the switch fabric;

upon a failure of one of the communications links, sequentially implementing the at least one path activation command for each of the path entries of the particular protection path activation list associated with the failed link.

22. The method of Claim 21 further comprising at each node:

maintaining a working path deactivation list for each communications link in the network, each list comprising an ordered listing of path entries, each path entry associated with a particular working path for that communications link and including at least one path deactivation command for effecting deactivation of one of the working path connections between ports of the switch fabric;

upon the failure of one of the communications links, sequentially implementing the at least one path deactivation command for each of the path entries of the particular working path deactivation list associated

with the failed link prior to implementing the at least one path activation command of the corresponding protection path activation list.

23. The method of Claim 21 further comprising at each node:

specifying a path data rate and the particular input and output ports for the protection path connection in each path entry of the path protection lists;

monitoring available capacity of each switch fabric output port;

maintaining a drop list for each switch fabric output port, each drop list comprising an ordered listing of path entries, each path entry including at least one path deactivation command for effecting deactivation of a path connection using that switch fabric output port;

wherein sequentially implementing the at least one path activation command includes comparing the path data rate with the monitored available capacity for the corresponding switch fabric output port; if the protection path data rate is greater than the available port capacity, sequentially implementing the at least one path deactivation command for path entries of the drop list until either the drop list terminates or the available port capacity exceeds the path data rate.

24. In a network of nodes interconnected by communications links and having a plurality of working paths, each working path including a working path connection between ports of a switch fabric in each node of a series of interconnected nodes, apparatus in a node for protection path switching, the apparatus comprising:

a memory;

a protection path activation list stored in the memory for each communications link in the network, each list comprising an ordered listing of path entries, each path entry associated with a particular working path for that

communications link and including at least one path activation command for effecting activation of a protection path connection between ports of the switch fabric;

a path protection accelerator for retrieving the protection path activation list from the memory and sequentially implementing, upon a failure of one of the communications links, the at least one path activation command for each of the path entries of the particular protection path activation list associated with the failed link.

25. The apparatus of Claim 24 further comprising:

a working path deactivation list stored in the memory for each communications link in the network, each list comprising an ordered listing of path entries, each path entry associated with a particular working path for that communications link and including at least one path deactivation command for effecting deactivation of one of the working path connections between ports of the switch fabric;

wherein the path protection accelerator is operable to retrieve the working path deactivation list from the memory upon the failure of one of the communications links, and sequentially implement the at least one path deactivation command for each of the path entries of the particular working path deactivation list associated with the failed link prior to implementing the at least one path activation command of the corresponding protection path activation list.